Quantifying parcelization potential of forest lands in Itasca County, north central Minnesota

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Introduction

Land parcelization is one of several factors contributing to forest fragmentation, which in turn has been linked to numerous environmental degradations, including declines in water quality (Dillon *et al.* 1994), wildlife habitat (Brooks 2003), and reduced access to the public for hunting and recreational pursuits. Parcelization, the division of tracts of land into smaller holdings, is often accompanied by changes in ownership, land use/land cover and public access, and development. The increased trend toward divestiture of land holdings by forest product companies, which potentially leads to parcelization, is well-documented in Minnesota and elsewhere. The Phase 1 report of the Minnesota Statewide Conservation and Preservation Plan identified habitat degradation, fragmentation, and consumptive use of land (conversion of land through development and associated infrastructure) as three of the main drivers of change affecting Minnesota's land resources (Swackhamer *et al.* 2008).

Mundell et al (Mundell *et al.* 2009) recently completed an analysis of forest parcelization using land records from Itasca County. Additionally, by using Minnesota Department of Revenue records from 1995 through 2006, they were able to identify subdivisions of ~40 acre parcels. They were also able to quantify changes in property tax classifications (e.g. forest undeveloped land to residential land), and assess the number and rate at which parcels were ultimately developed (changes in land value associated with presence of structures on the property). They found that parcelization rates for Itasca County were about 0.4% per year, or approximately half the typical rate of forest harvest (~1.0% per year). With the exception of 2002, when the elimination of Minnesota's Tree Growth Tax Law caused a spike in the percentage of parcels classified as forest undeveloped land, the rate of parcelization has been relatively constant at 45-50 divisions per year across the county.

There were strong spatial variations associated with parcelization. Parcelization was greatest near municipalities – high rates were observed near the cities of Grand Rapids and Deer River. Parcelization was positively associated with proximity to water and to public lands. The findings from this and other research provide a basis for a county-scale regional assessment of the relative potential for parcelization of private lands. *The objectives of this study were to assess and map the relative potential for parcelization on private lands within Itasca County, and relate parcelization risk to a critical habitat database developed as part of the Statewide Plan for Conservation and Preservation.* Understanding the distribution and ownership patterns of these lands can help land managers select the most appropriate conservation strategies. In addition, the analyses described here demonstrate a spatial modeling approach that can be used to help target conservation efforts in other regions of the state.

Methods

Study area

This study was conducted in Itasca County, which covers approximately 3,000 mi^2 in north central Minnesota, and includes 16 municipalities and 42 organized townships. The county is heavily forested, contains over 1,000 lakes, and comprises a broad mix of public and private lands. The county contains segments of three diverse ecological sections: the Minnesota and Ontario Peatlands, the Drift and Lake Plains, and the Northern Superior Uplands (MN DNR). This north central region of the state has been subject of a large body of research, including spatial analyses of disturbance patterns (White & Host 2008), modeling the range of natural variation (White & Host 2000), a conservation legacy assessment for Itasca County, and numerous habitat and water resource studies.

Spatial Analyses: Parcelization Risk

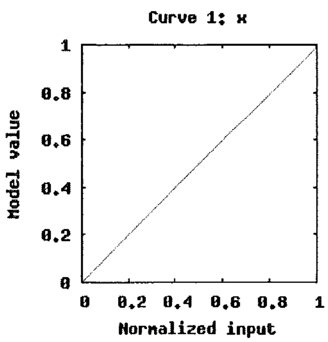
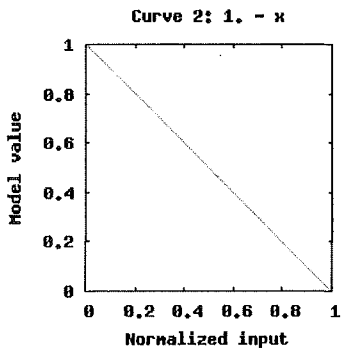
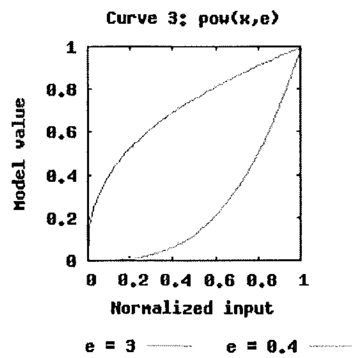
Parcelization risk was modeled using a number of factors known to be correlated with parcelization. Geospatial data used in the model are presented in Table 1. All data sets were gridded to 30 m, the resolution of the original LANDSAT data that formed the basis for many of the MN DNR GAP habitat data sets (land use, ownership, land stewardship, and others). Many 'distance variables' were modified with weighting functions - for example 'distance from water,' a negative factor, was described by the actual distance up to 500 meters, and clipped to 500 beyond that, effectively removing the influence of this variable (Table 2). All of the variables were 'normalized,' i.e., the minimum value of a given data set (usually zero) was subtracted from all values in the data set, and the resulting values were divided by the difference between the minimum and maximum values in the data set. Normalizing the values in this way makes it possible to map their combined effects simply by adding them up for any given piece of land.

Table 1. Spatial data sources and analysis models for parcelization risk modeling. Percentages represent contribution of layer to composite parcelization index

Factor	Data Source	Analysis model
Distance to water	DNR 1:24,000 hydrography	Distance to lakes > 32 ac, negative linear to 500 m, 25.8%
Wetland density	National Wetland Inventory	Proportion of wetland in 1 km radius, negative linear, 3.2%
Proportion of public land	DNR Gap Ownership	Proportion of public land in 1 km radius, positive linear, 3.2%
Land stewardship category	DNR Gap Stewardship	Categories 1-4, positive parabolic, 32.3%(approx. red line)
Distance to municipality	ESRI municipalities	Negative linear up to 10,000 m, 3.2%
Distance to major road	TIGER roads	Negative linear up to 3,000 m, 32.3%

Potential for parcelization was determined for each 30 m pixel as a weighted index function of the above factors. The mean parcelization risk was calculated for each individual parcel, and parcels ranked by the risk index. The composite parcelization index was used to generate maps showing the top 0.5% and 1% at-risk parcels (summarized by area).

Table 2. Weighting models for parcelization risk variables.

		
Positive linear model: Distance to water, proportion of public land	Negative linear model: Proportion of wetlands	Parabolic model: GAP land stewardship category

Spatial Analyses: Critical Habitat

As part of the Statewide Plan for Conservation and Preservation, we developed maps of critical terrestrial and aquatic habitat. The primary goal of this habitat mapping was to compile information available on a statewide basis that could be used to prioritize important areas for conservation. The analyses integrated both positive (resources) and negative (threats to resources) information on biodiversity, habitat quality, outdoor recreation (e.g., hunting and fishing), and water quality. Positive components included features such as known occurrences of rare species, sites of biodiversity significance, or high levels of game species abundance. Negative components included the dominant drivers of environmental change as identified in Phase I of the Statewide Conservation and Preservation Plan. Negative influences on natural resources included human development, land use, and road density. By acquiring and objectively processing information related to these components, it was possible to rank areas in Minnesota according to their conservation priority. As in the parcelization analyses, data were derived or gridded to 30 m cells. Twelve terrestrial data sets were identified and compiled from a variety of sources (Table 3).

Table 3. Input datasets and weightings for critical habitat analyses.

Input	Weighting	Description
Sites of biodiversity significance	33	A multi-faceted assessment of this land for its importance from a regional perspective in terms of biodiversity and ecosystem function. Higher values indicate higher biodiversity significance.
MN DNR GAP terrestrial vertebrate models - Game species	7	The number of game species for which this land may be habitat. Higher values indicate higher numbers of game species potentially using this land.
MN DNR GAP terrestrial vertebrate SGCN models	10	The number of Species of Greatest Conservation Need (SGCN) for which this land may be habitat. Higher values indicate higher numbers of SGCN species potentially using this land.
Bird potential habitat models – USGS	9	Probable number of bird species (from a set of 17) using this land. Higher values indicate a greater number of species.
MN DNR GAP Habitat by protection level	8	Number of terrestrial vertebrate species potentially using this land weighted by the current level of habitat protection statewide for each species. Higher values indicate more species potentially using this land, weighted as described.
Wildland Urban Interface	6	Wildland Urban Interface maps initial encroachment of development into areas of largely intact natural cover. Decisions made here determine whether natural areas are preserved or pressured. Higher values indicate land classified as Wildland Urban Interface, this is a binary yes / no input.
Wildland Urban Intermix	5	Wildland Urban Intermix map intermixing of development and significant natural cover. Connectivity can be maintained or lost by decisions made in these areas. Higher values indicate land classified as Wildland Urban Intermix, this is a binary yes / no input.
CRP lands	5	Lands enrolled in the Conservation Reserve Program, USDA.
Road density	5	A measure of the density of roads within the township. Major roads receive a higher weighting. Higher values indicate higher density of roads in the township.
Housing density 2000	4	Housing density from census data (census blocks) for 2000 for this land. Higher values indicate higher housing density.
Projected housing density 2030	4	Projected housing density by census blocks for 2030 for this land. Higher values indicate higher projected housing density.
Housing density change 2000 to 2030	5	Projected change in housing density by census blocks for 2000 to 2030 for this land. Higher values indicate higher housing density increase.

Each of these data sets contributed to estimating the conservation value of a piece of land, and spatial data layers were combined to produce an integrated map. Some of these factors were binary, e.g. whether land is in or out of the Conservation Reserve Program. Others, like sites of biodiversity significance (SOBS), were mapped in ranked classes (medium, high, and outstanding), which were converted to ordinal ranks. Most of the data sets had continuous numeric ranges. Bird habitat models, for example, record the probability of a species occurring at a location as a number between 0 and 100. Seventeen continuous models were included in the analysis. Individual contributing layers were weighted based on relative importance, with weights derived by a Statewide Conservation and Preservation Plan working group. As an example, for a given piece of land the integrated value could be 33% dependent on its SOBS class, 5% dependent on its CRP status, and 4% dependent on its housing density in 2000.

To assess the risk to high quality habitats, we evaluated the correlation between these variables and identified parcels with both high habitat value and high parcelization risk.

Results and Discussion

The full parcel dataset for Itasca County consists of over 10,000 parcels covering over 1,800,000 acres. The state of Minnesota is the largest land owner, with about one third of the land base in state or tax forfeit status. The federal government owns another 15%. In terms of private ownership, Blandin Paper Company, with 154,900 acres (8%), is the largest single private landowner. Meriwether Minnesota Land and Timber hold about 2% of the land base (35,350 ac), and Boundary Company, US Steel Corporation, and Potlach Corporation also have significant land holdings (10,000 to 35,000 acres). The remaining 40% of Itasca County lands are held by just over 24,800 independent landowners, with 21,000 of these owning less than 40 acres. The following results focus on the approximately 3,800 landowners holding 40 or more acres.

The different layers contributing to parcelization risk showed a wide range of spatial variation and heterogeneity, as shown in Figures 1-5, which show data from a 210 mi^2 landscape in northern Itasca County. Road densities are generally high throughout the county, but a relatively large portion of the area lacks major roads (Figure 2). The map of distance to streams and lakes <32 acres isolates a much smaller portion of the landscape, with most of the area beyond the 500 m distance threshold (and consequently not contributing strongly to parcelization risk; Figure 3). Wetlands are much more pervasive across the landscape compared with lakes and stream networks (Figure 4).

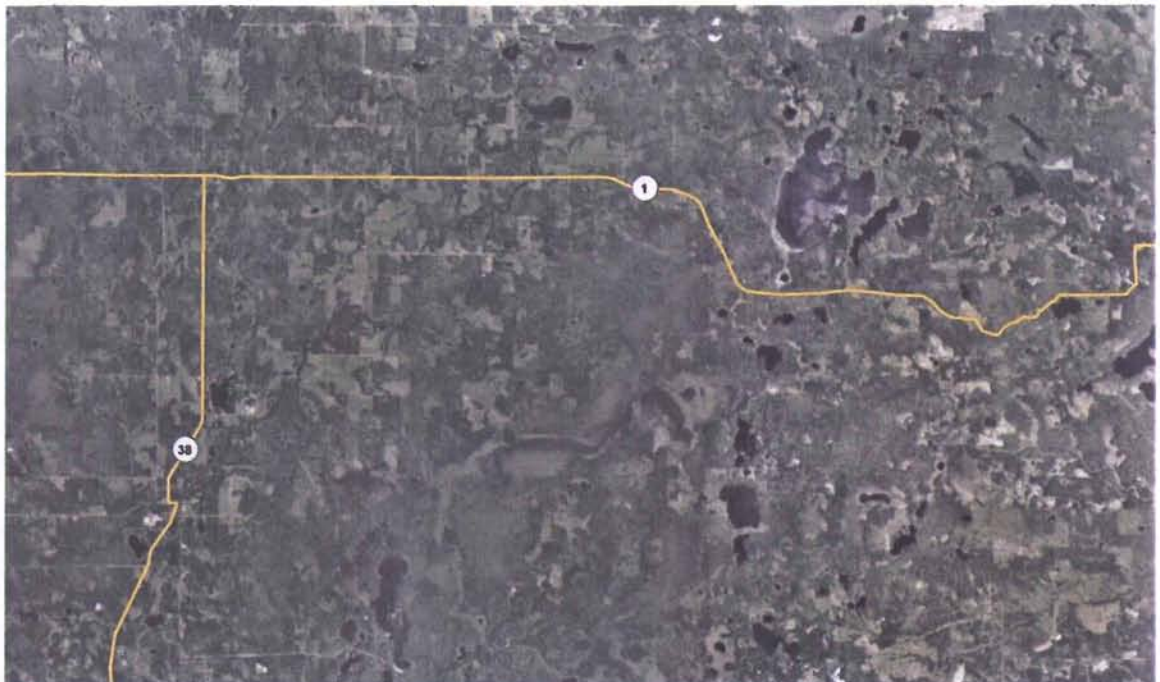


Figure 1 Aerial photo of 210 mi^2 example region of northern Itasca County. Figures 2-5 and Figure 7 are based on this footprint.

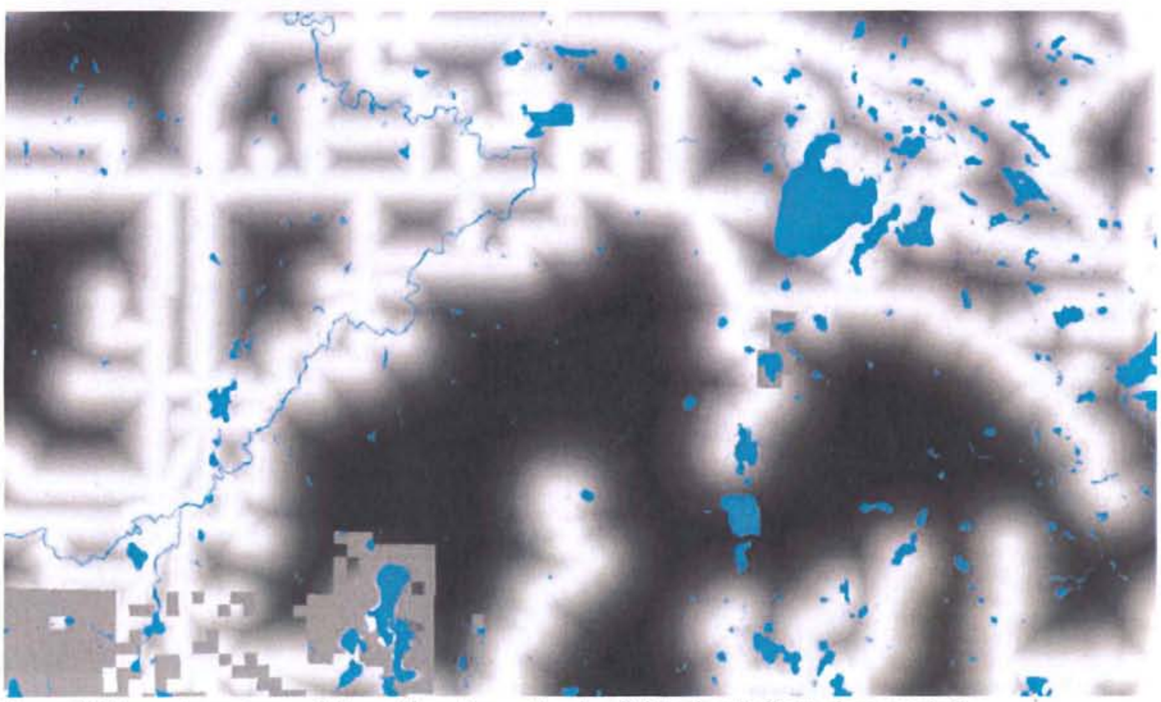


Figure 2 Distance to major roads in northern Itasca County - light colors indicate close proximity.

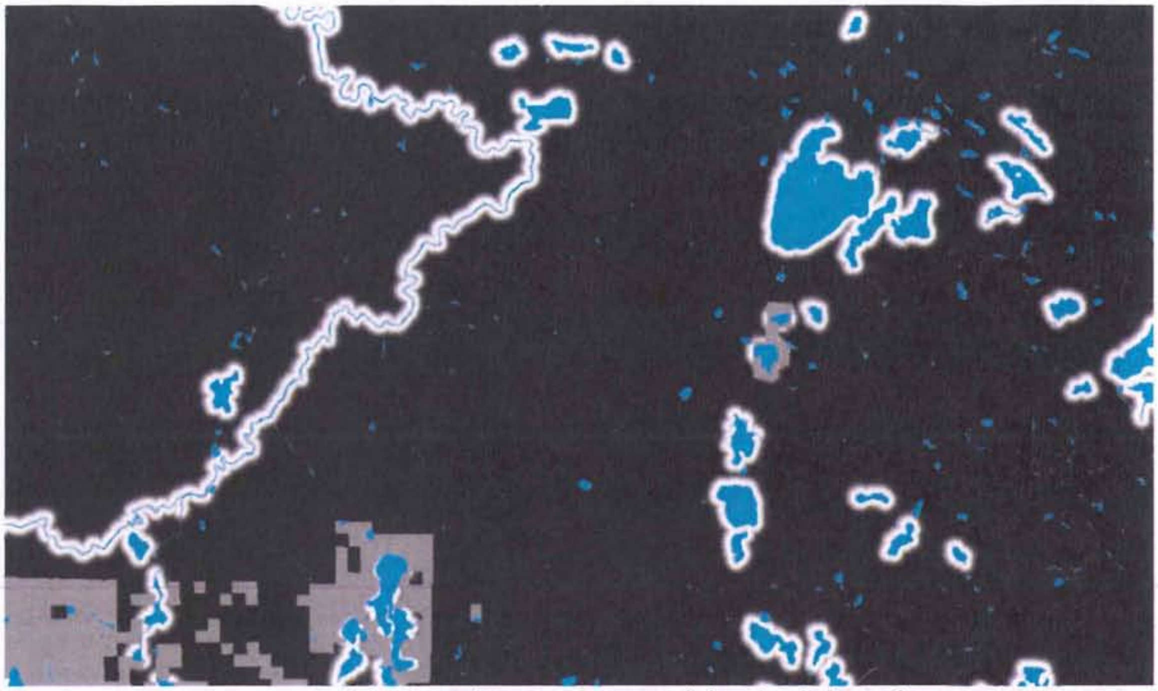


Figure 3. Distance to streams and lakes in northern Itasca County - light colors indicate close proximity.

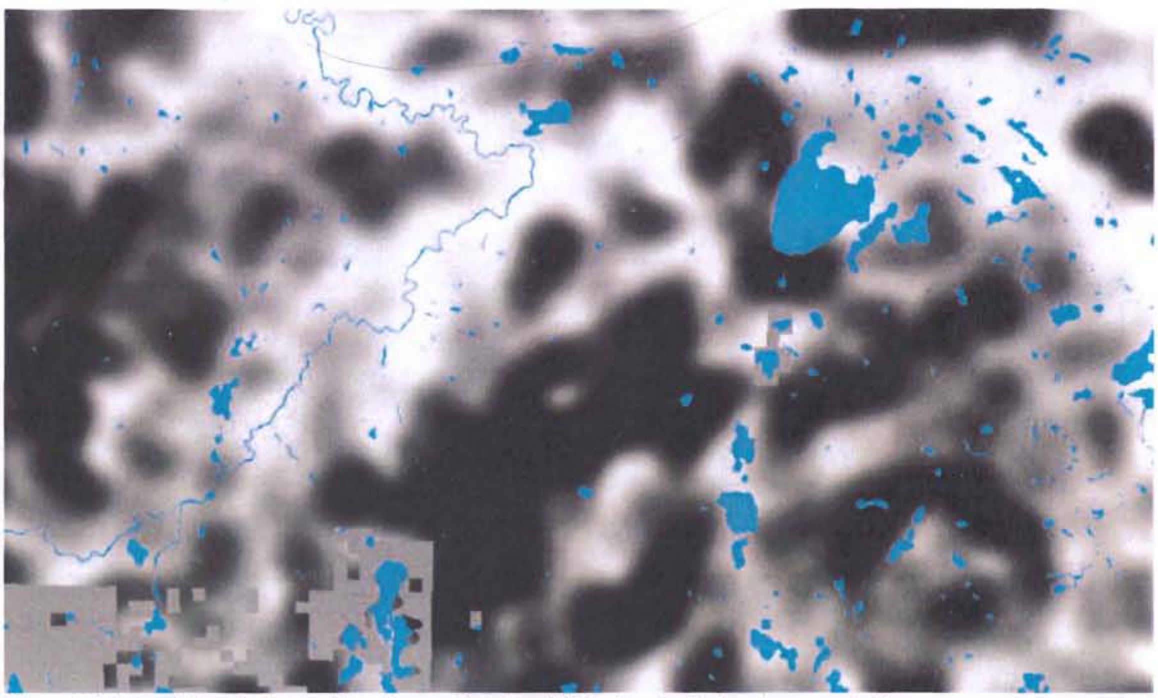


Figure 4 Wetland density in northern Itasca County - light colors indicate close proximity.

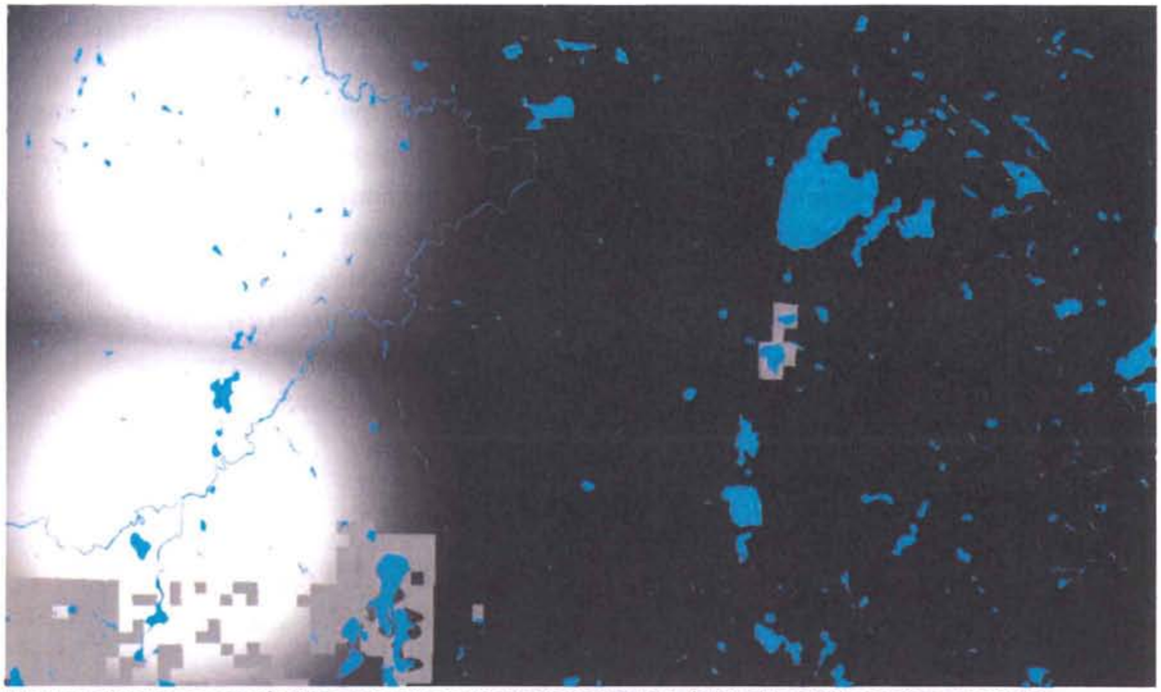


Figure 5 Distance to population centers in northern Itasca County - light colors indicate close proximity.

The risk index, formed as the sum of the weighted layers, scaled between 0.0 and 0.15. The distribution of the risk index was bimodal, with peaks at intermediate low and intermediate high values (0.7 and 0.11, respectively; Figure 6). The distribution also varied from normality by having extended tails, with the right tail of the distribution represent parcels with the highest parcelization potential.

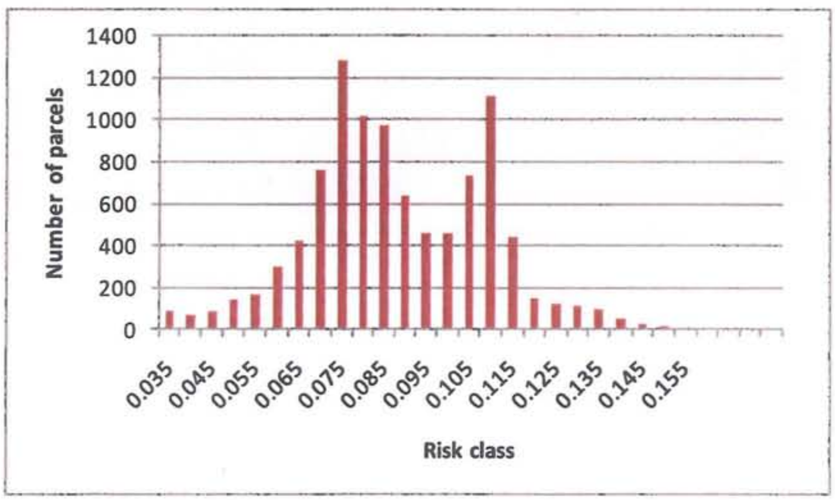


Figure 6. Frequency distribution of parcels by risk index.

The resulting map of the parcelization risk index isolates areas where the combined effect of individual layers leads to high levels of parcelization risk (Figure 7). The map shows heterogeneity at several spatial scales - risk is distributed at fine spatial scales along key areas such as lakeshores, but also more broadly in areas of low-density development. The analysis also shows numerous privately held areas where probability of parcelization is low. Parcelization risk distributed across the entire county is presented in Figure 8. The 'protected' lands are within the Chippewa National Forest or have some existing protection status (e.g. scientific and natural areas, state parks). Itasca County also has numerous parcels currently under conservation easements, including over 10,000 on Forest Capital Partners lands in northeastern Itasca County (part of a 50,000+ ac easement shared with Koochiching County, and a 1,660 ac tract of northern hardwoods in southern Itasca Co.

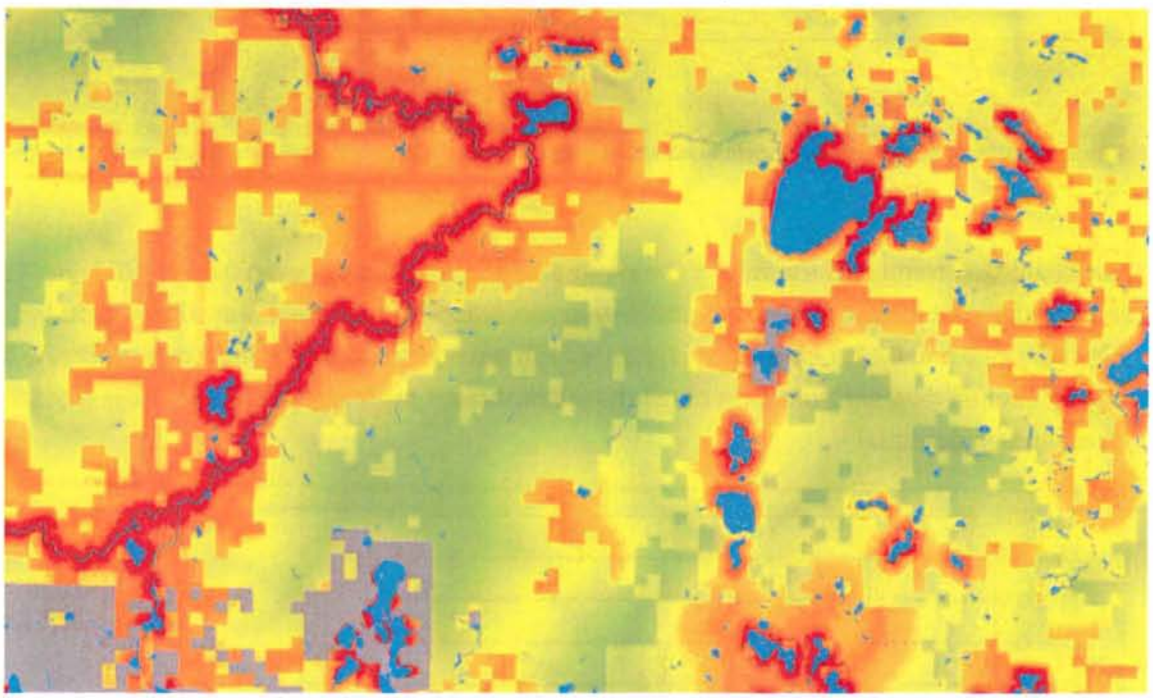


Figure 7. Composite map of parcelization risk in northern Itasca County. Red - high risk, green - low risk, gray - protected area, blue - water.

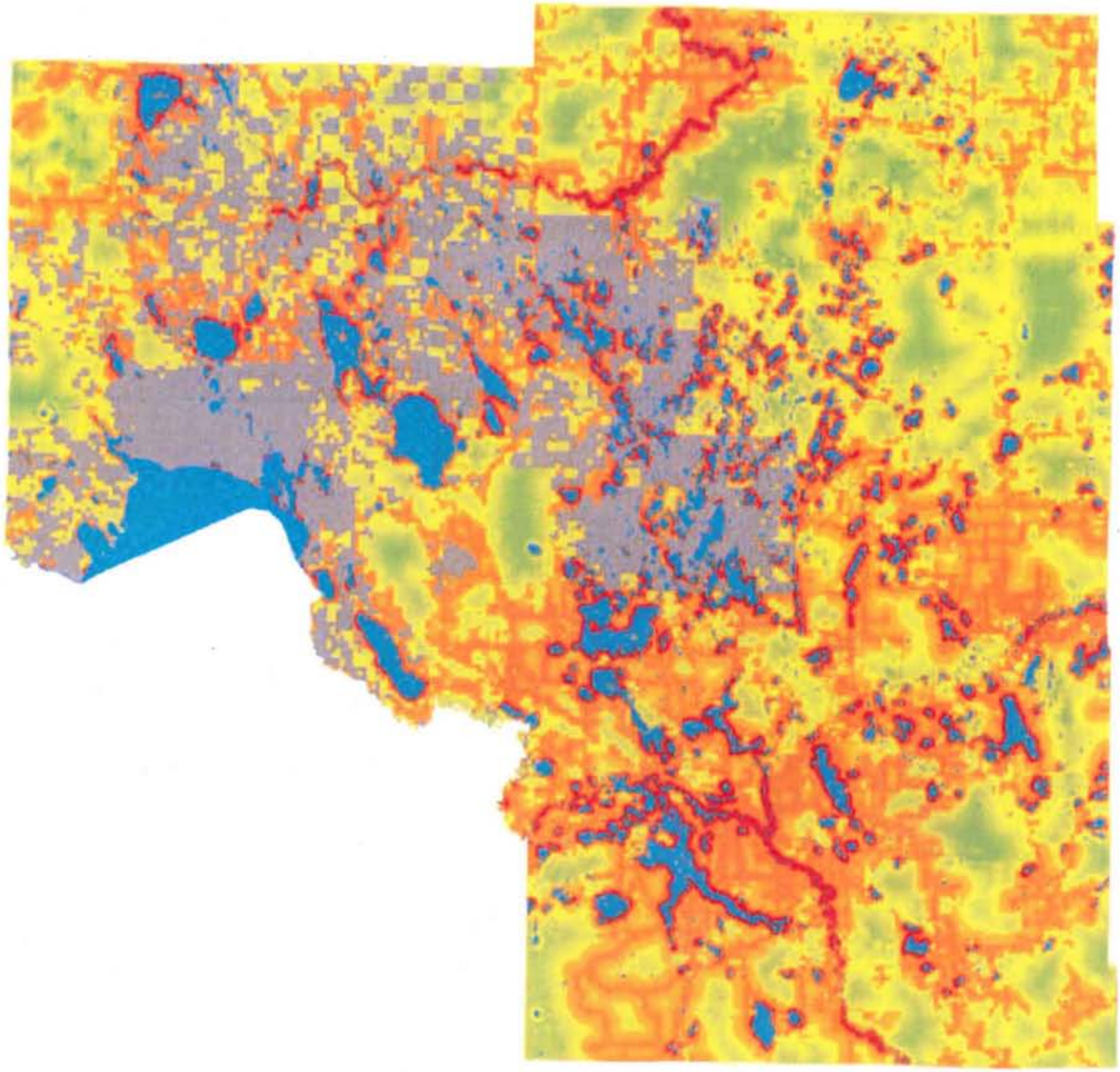


Figure 8. Map of parcelization risk for Itasca County Composite map of parcelization risk in northern Itasca County. Red - high risk, green - low risk, gray - protected area, blue - water.

We assessed patterns of ownership in the highest risk categories, defined as the top 0.5% based on acreage – the half-percent cutoff was approximately 7,500 acres (Figure 9). Of these high-risk ownerships, 66% of the land was in 'family forest,' 25% was held by corporations (including foundations and camps), and 10% was in public ownership (municipalities, counties). A few groups had relatively large land holdings (US Steel Corporation – 412 ac; city of Deer River 322 ac), but most parcels ranged from 40-60 acres. This indicates that privately-held family forests might be the most effective group for targeting conservation easements or other policy tools designed to reduce forest land parcelization.

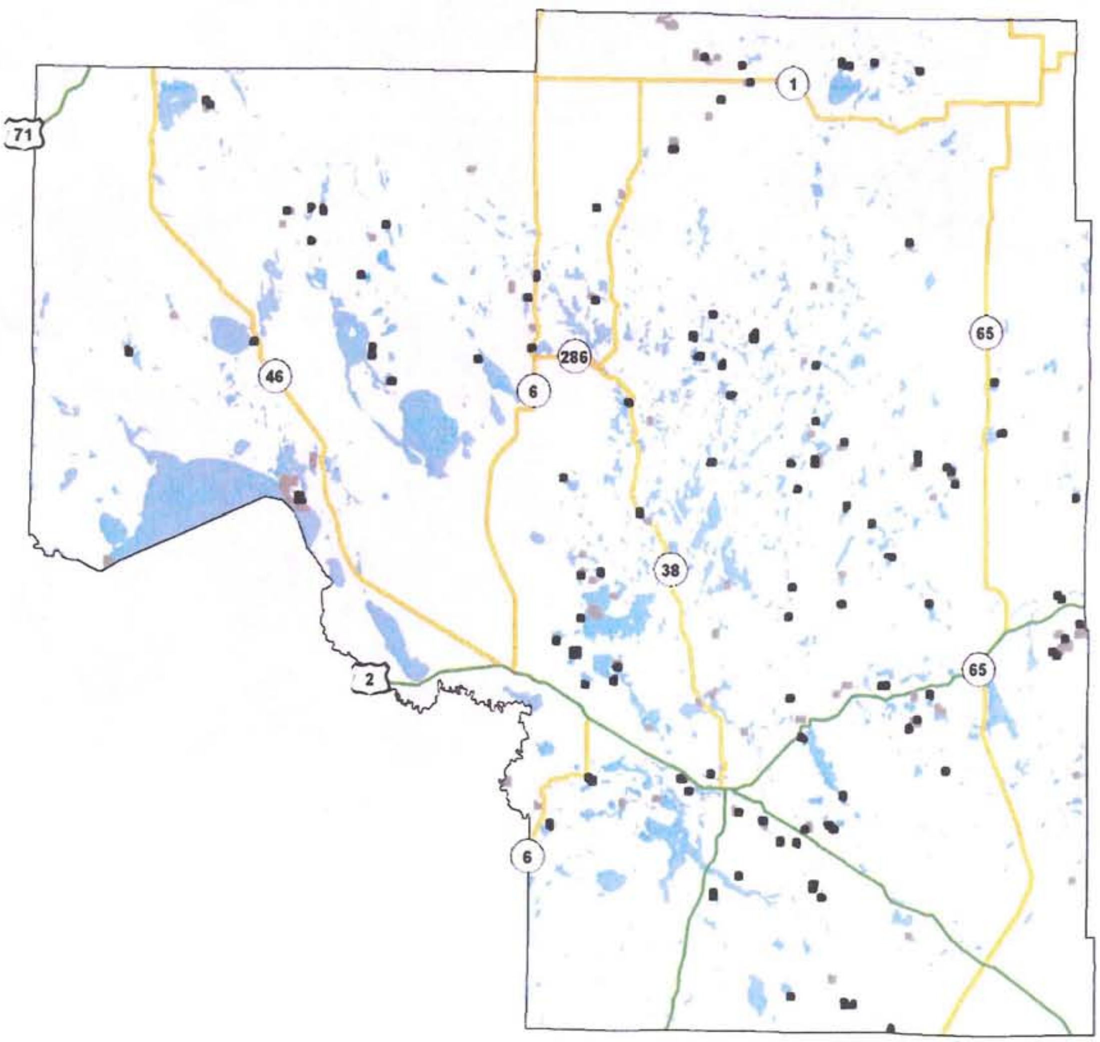


Figure 9. 40 acre tracts with the highest parcelization risk (black top 5%, gray top 5-10%).

The curve describing habitat quality had three distinct phases - region of relatively high habitat quality, consisting of 2,400 acres of index values above 0.65, a relatively steep transition, and ~7,000 acres of relatively low habitat quality (< 0.30; Figure 10). This habitat index was used to produce an integrated map that cross tabulates parcelization risk and habitat quality (Figure 11).

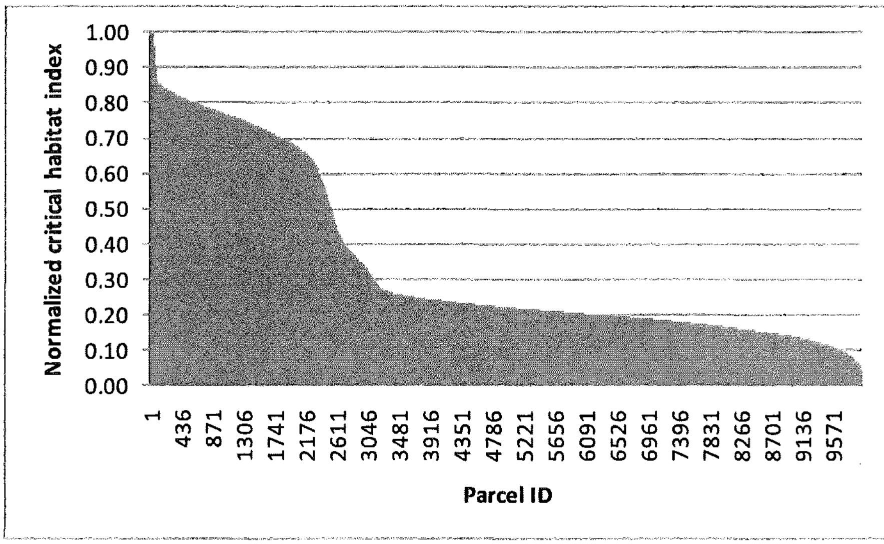


Figure 10. Distribution of normalized critical habitat index.

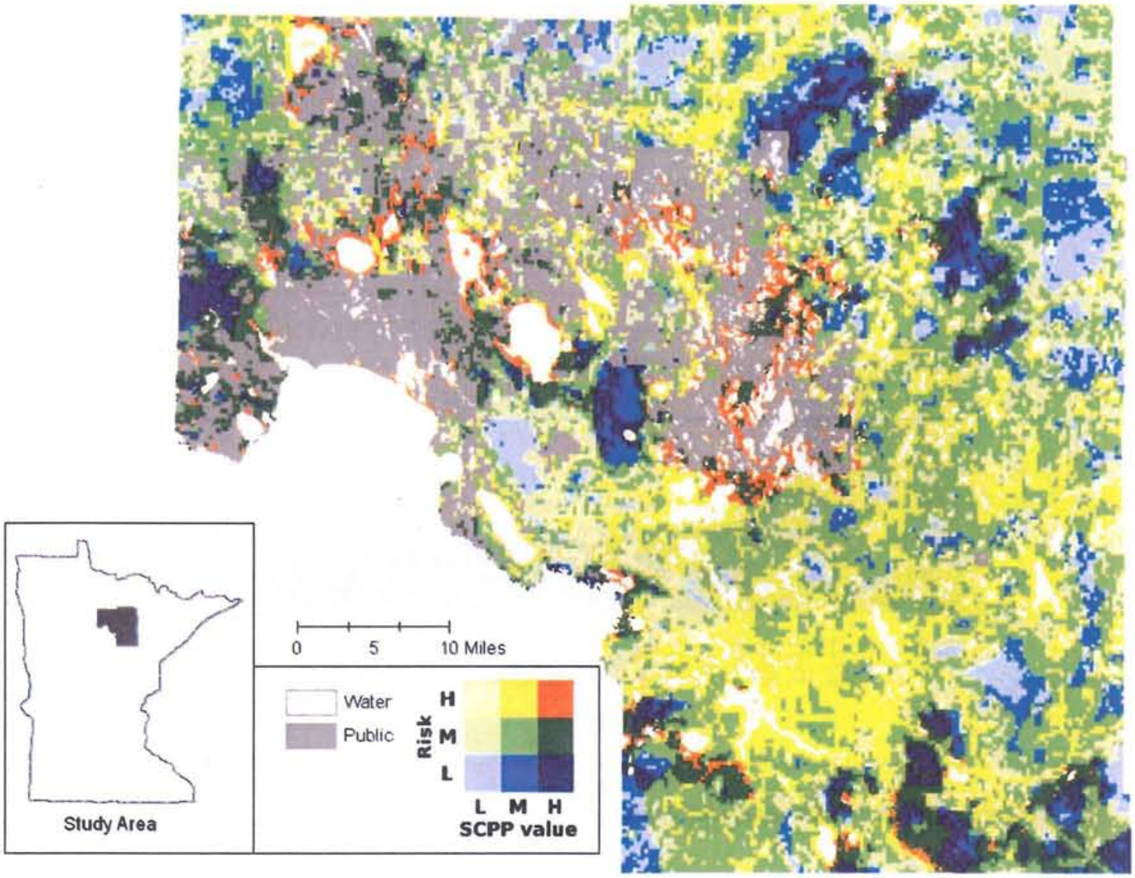


Figure 11. Integrated map showing intersection of parcelization risk and habitat value from the Statewide Conservation and Preservation Plan. Areas with both high risk and high value shown in orange.

The habitat index was not correlated with parcelization risk ($r^2 = 0.002$); i.e. highly ranked habitat parcels were not selectively subjected to increase risk of parcelization. It is possible, however, to identify a set of parcels having both high habitat value and high parcelization risk. We identified 33 parcels totaling 1,428 acres with habitat values > 0.70 and parcelization risk >0.15 (Figure 9). Twenty-four of these were 'family forest' parcels; others were held by Limited Liability Partnerships (LLPs), foundations, or companies. The ability to integrate habitat quality and risk provides a means for resource management agencies to target specific key properties for acquisition, conservation easements, or other conservation efforts.

The maps and analyses produced in this study identify parcels that, based on multiple criteria including distance to water, roads, and public lands, are at increased risk of being subdivided. The maps further show which classes of owners currently hold high-risk lands, and provides guidance on where to target conservation and protection efforts. The inclusion of critical habitat data from the Statewide Conservation and Preservation Plan shows that there is not a significant correlation between habitat quality and conservation risk. The use of this critical habitat data, however, provides a further filter to identify those high quality lands that also have high risk of parcelization.

Acknowledgements

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